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Title: Overview of the Radiological Design of the New PF-4 Staging Gloveboxes

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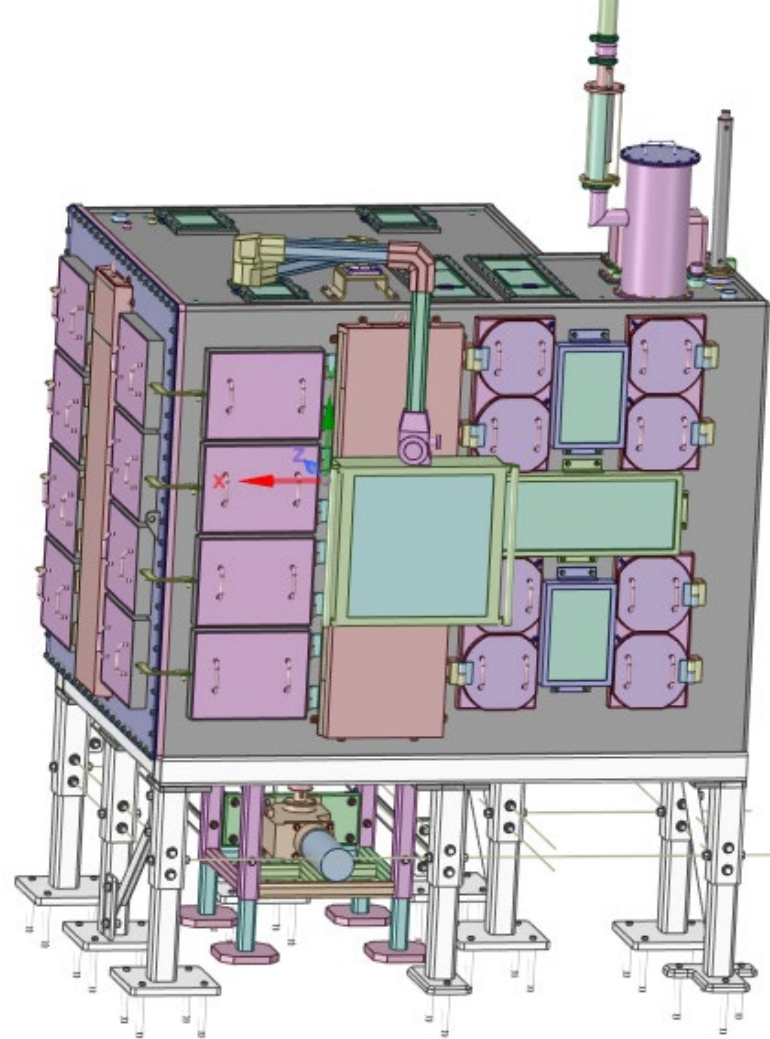
Overview of the Radiological Design of the New PF-4 Staging Gloveboxes

Lucas D. Hetrick

February 10th, 2021

Outline

- Introduction
 - Purpose of Staging Gloveboxes
 - Radiological Source Term
 - Design Objectives
- Modeling Process
 - Geometry
 - Calculation Setup
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 - Selection of Neutron Shielding Material
 - Removal of Superfluous Shielding Features
 - Relocation of Neutron Shielding
- Conclusions



Introduction: Purpose of Staging Gloveboxes

- Support Increased Pit Production Mission
 - Provide easy access to feed material
 - Convenient staging of various parts
 - Convenient staging of SNM waste



Introduction: Radiological Source Term

- Material
 - MT-52 aged up to 50 years
 - Up to 96 kg in gloveboxes at any given time
- Occupancy
 - Primary Workstation: 100 h per y
 - Maintenance Workstations: 20 h per y
 - Numerous operations in vicinity of gloveboxes



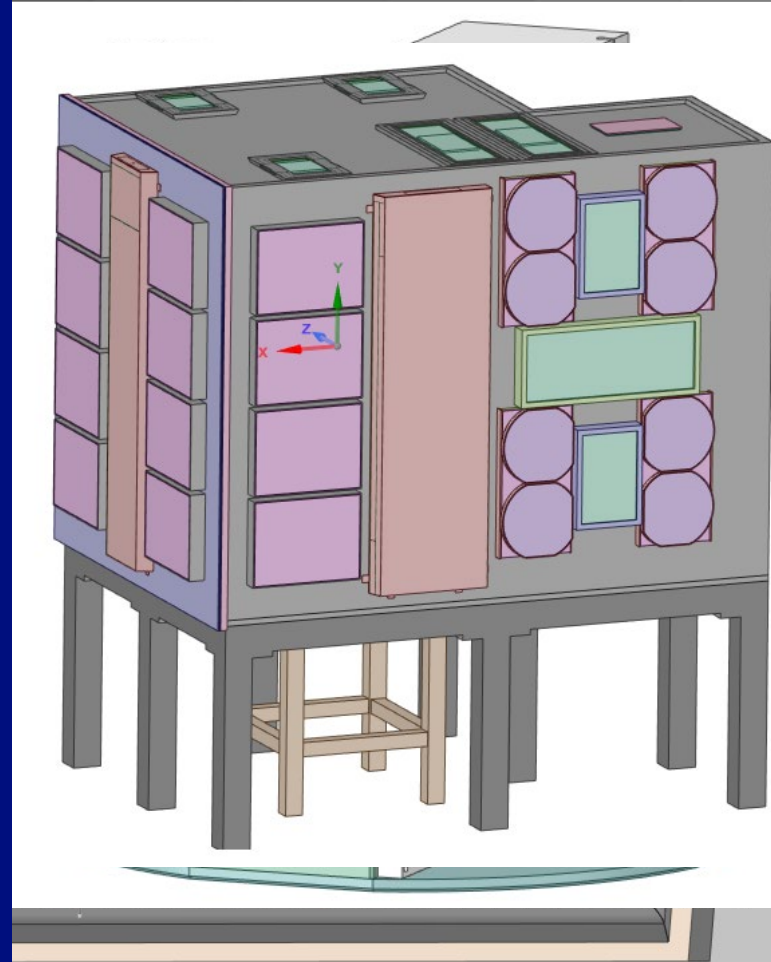
Introduction: Design Objectives

- Chapter 12 of Appendix A of P121, *Radiological Protection*
 - *For a continuously occupied area, the design must maintain the average radiation exposures levels below an average of 0.5 mrem per hour and ALARA.*
 - *For noncontinuously occupied areas, the design must ensure the radiation exposure levels are ALARA and below the applicable standards [1,000 mrem per y]...*
- *ALARA Design Objective established based on purpose of gloveboxes and occupancy of nearby operations*
 - *250 mrem per y*



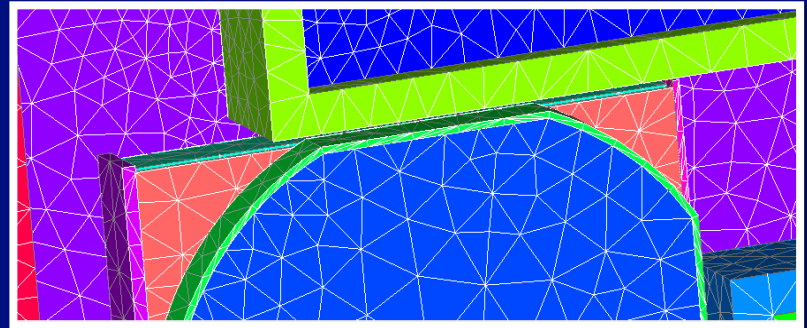
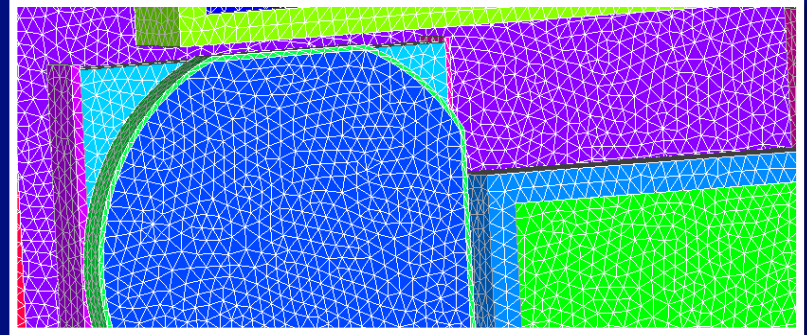
Modeling Process: Geometry

- Issues with provided CAD model:
 - Superfluous features such as bolts, fillets, handles, gaskets, etc. present which complicate radiation transport and meshing geometry.
 - Many small gaps or holes were present throughout which caused issues with meshing geometry



Modeling Process: Calculation Setup I

- Mesh Generation:
 - Balancing act between number of voxels and accurate geometry representation.
- Mesh Challenges
 - Difficulty modeling air inside of glovebox due to presence of tiny complicated shapes.
 - Attila personnel recommended filling glovebox with void to bypass issue.



Modeling Process: Calculation Setup II

- Cross Section Library:
 - Fendl
- Material Specification
 - *PNNL-15870 Rev. 1: Compendium of Material Composition Data for Radiation Transport Modeling*

Input Editor: Final_Shielding_Configuration* [Project: Staging_Glovebox]

Panels

- General
- Mesh Geometry
- Cross Section Library
- Energy Group Attributes
- Material Editor
- Region Attributes
- MCNP Controls
- Fixed Source
- Boundary Values
- Solver Controls
- Output Controls
- Custom Reports
- MCNP Importances

Materials

Material: **Leaded_Glass**

Density: 6.22 g/cc

Fraction units: Weight

Cross Section	Weight Fraction
o16-8016	0.156453
si-14000	0.080866
ti-22000	0.008092
pb206-82206	0.181217
pb207-82207	0.166178
pb208-82208	0.394016

Fission

☒ Non-Fission

☐ Use χ of isotope:

☐ Mix isotopic χ 's using library weighting flux

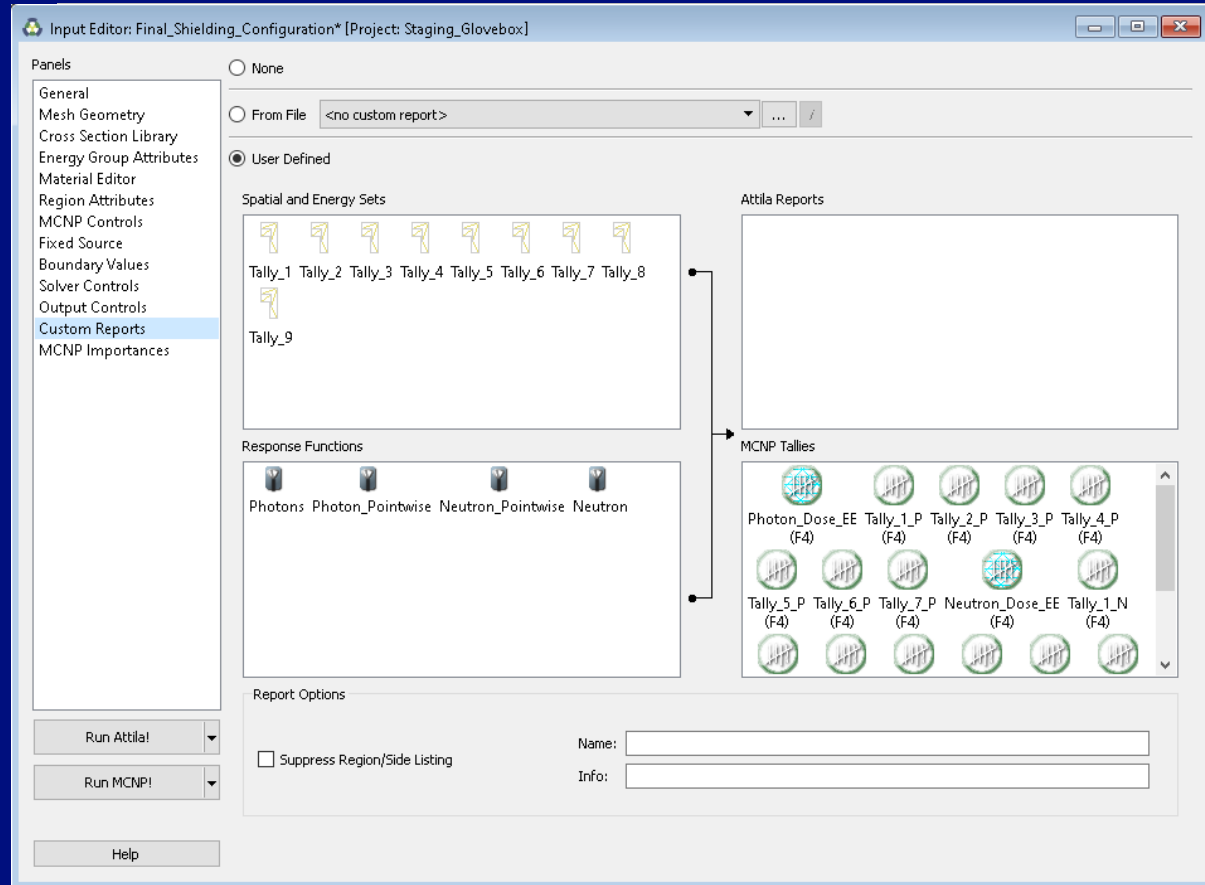
Cross Sections

Cross Section	Number	Formax ID
al27-13027	1	01302700
au197-79197	2	07919700
b-5000	3	00500000
b10-5010	4	00501000
b11-5011	5	00501100
be9-4009	6	00400900
bi209-83209	7	08320900
c12-6012	8	00601200
ca-20000	9	02000000
cl-17000	10	01700000
cl35-17035	11	01703500
cl37-17037	12	01703700
co59-27059	13	02705900
cr-24000	14	02400000
cr50-24050	15	02405000
cr52-24052	16	02405200
cr53-24053	17	02405300
cr54-24054	18	02405400
cu-29000	19	02900000
cu63-29063	20	02906300
cu65-29065	21	02906500
f19-9019	22	00901900
fe-26000	23	02600000
fe54-26054	24	02605400
fe56-26056	25	02605600
fe57-26057	26	02605700
fe58-26058	27	02605800
ga-31000	28	03100000
h-1000	29	00100000
h1-1001	30	00100100
h2-1002	31	00100200
h3-1003	32	00100300



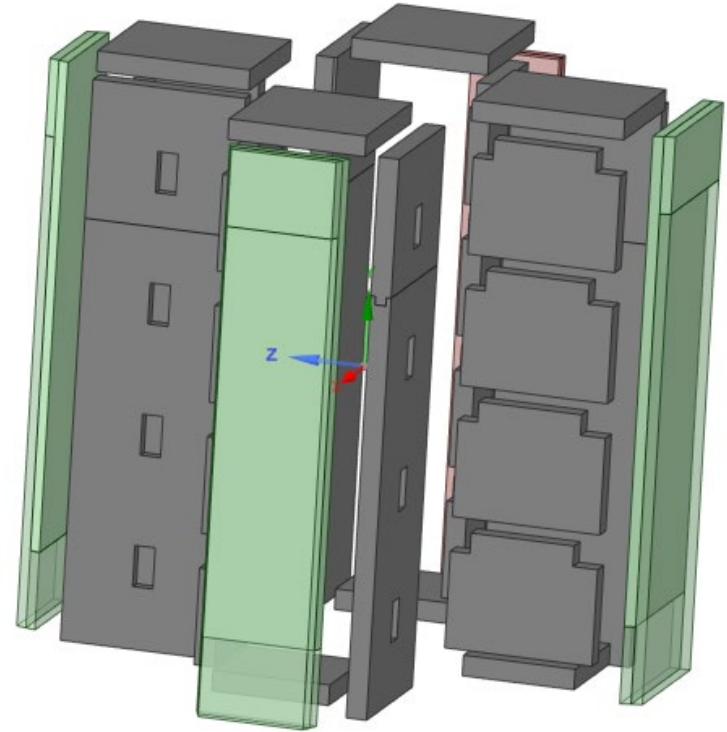
Modeling Process: Calculation Setup III

- Source Definition:
 - Spectrum generated with version 6.1 of ORIGEN
- Reports
 - *User specifies type of tally, location, DCFs, etc...*

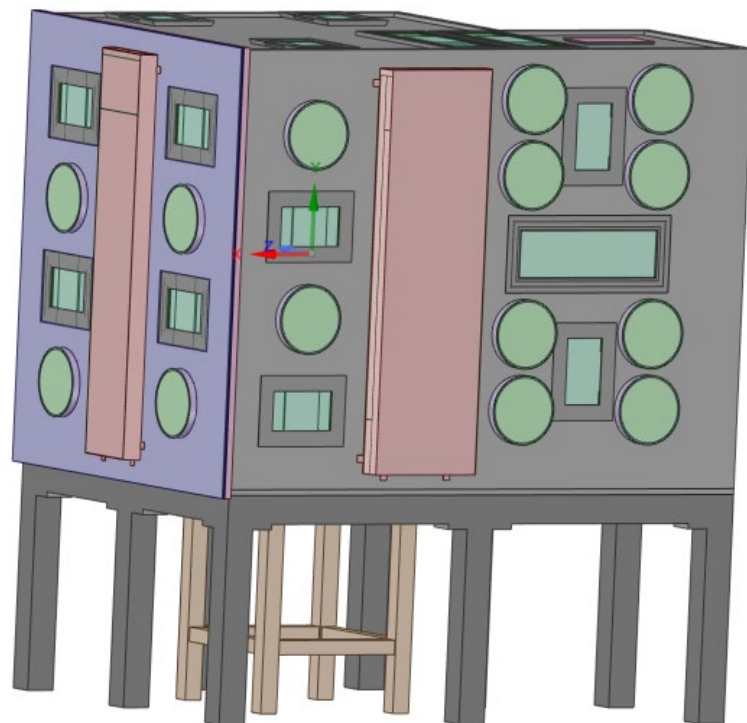
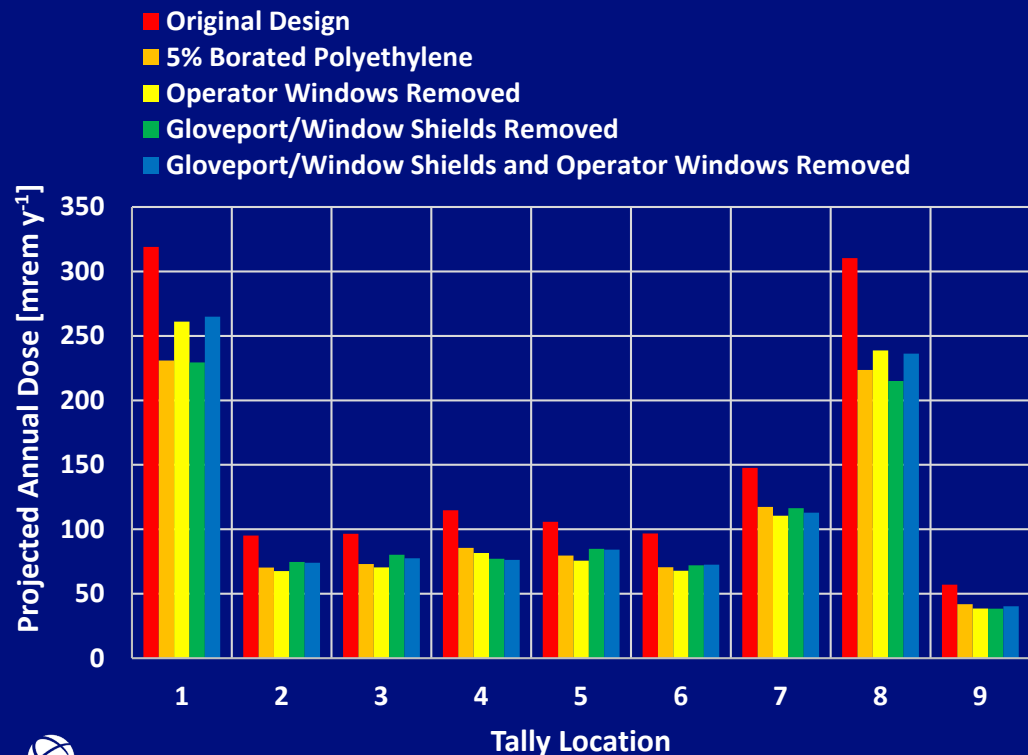


Results: Selection of Neutron Shielding Material

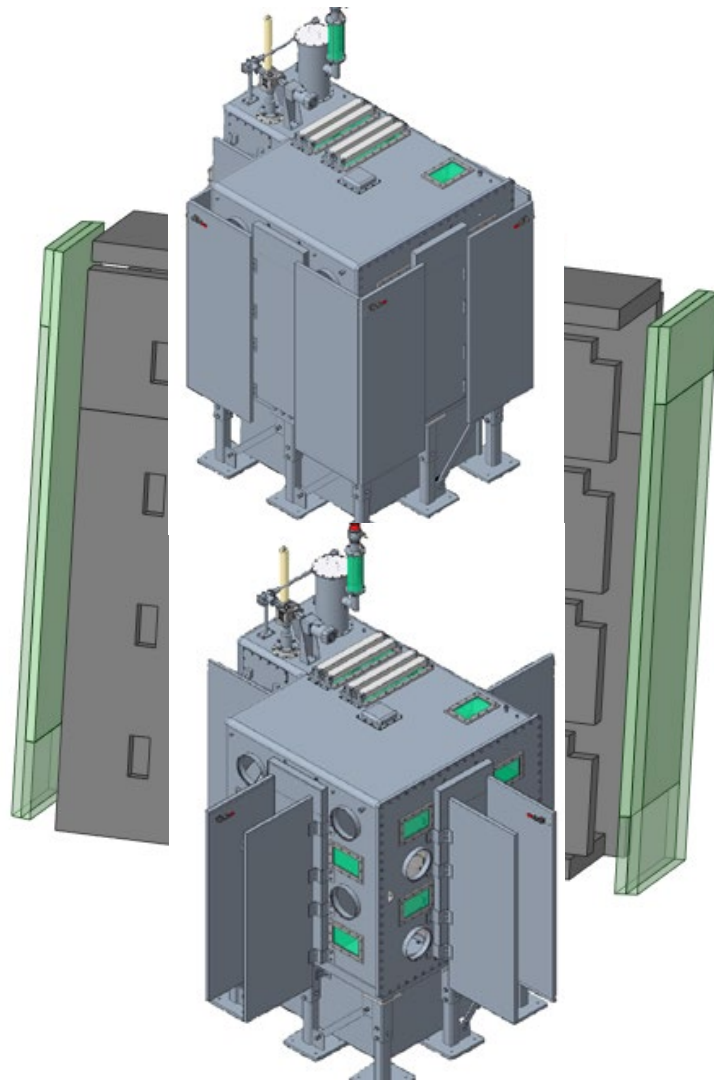
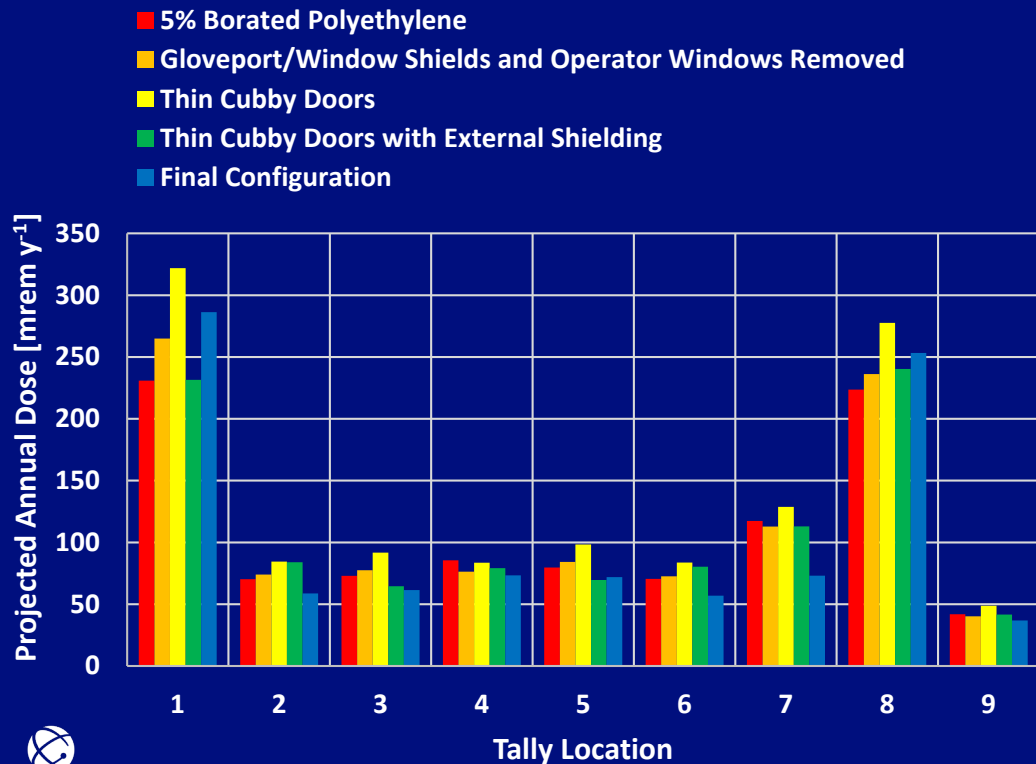
Tally	Polyethylene	Borated Polyethylene	Borated PMMA	Borated Water
1	100%	75%	85%	82%
2	100%	77%	85%	78%
3	100%	75%	85%	76%
4	100%	74%	86%	79%
5	100%	77%	86%	85%
6	100%	77%	86%	81%
7	100%	81%	83%	80%
8	100%	76%	85%	82%
9	100%	76%	94%	80%
Average	100%	76.4%	86.1%	80.3%



Results: Removal of Superfluous Shielding Features

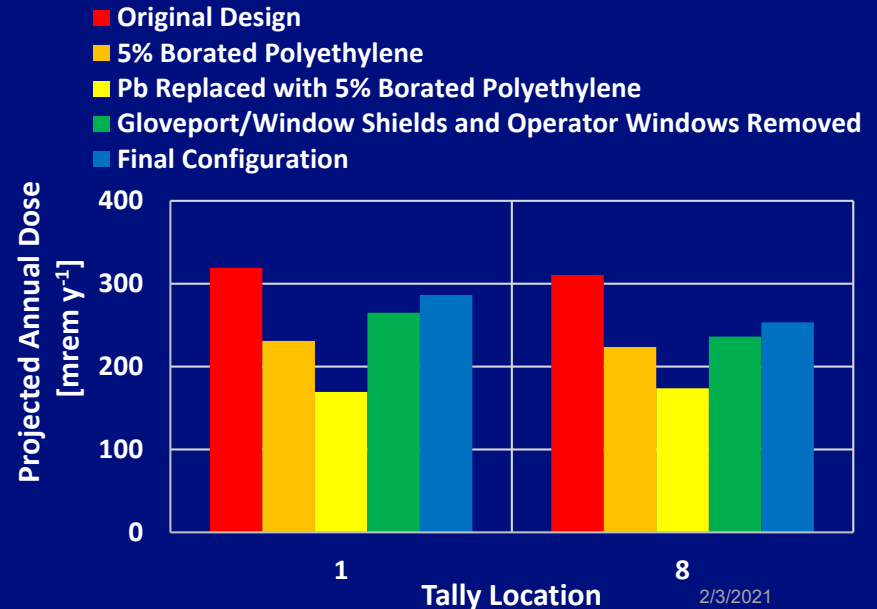


Results: Relocation of Neutron Shielding



Conclusions

- ALARA Design Objective
 - Dose Exceeded 250 mrem y^{-1} but considered ALARA given constraints
- Possible Improvements
 - Add additional neutron Shielding



Questions

